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Claims

[c1] 1. An intake/exhaust system for a dual-mode homogeneous charge compression ignition (HCCI) engine operable in SI and HCCI modes, said system comprising:
at least one cylinder including at least one intake valve and at least one exhaust valve; and
at least one cam operatively connected to said intake and exhaust valves;
wherein in SI mode, said cam operating said intake valve such that an intake cam movement event length is approximately 280 to 320 cad.

[c2] 2. The system according to claim 1, wherein said engine further comprising a piston disposed within said cylinder and including top dead center (TDC) and bottom dead center (BDC) positions, in SI mode, said system further comprising an intake valve closing time of approximately 90 to 120 cad after BDC.

[c3] 3. The system according to claim 1, wherein said engine further comprising a piston disposed within said cylinder and including top dead center (TDC) and bottom dead center (BDC) positions, in HCCI mode, said system further comprising an exhaust valve opening time of ap-

proximately 20 to 60 cad before BDC.

[c4] 4. The system according to claim 1, wherein said engine further comprising a piston disposed within said cylinder and including top dead center (TDC) and bottom dead center (BDC) positions, in HCCI mode, said system further comprising an intake valve closing time of approximately 20 to 50 cad after BDC.

[c5] 5. The system according to claim 1, wherein in HCCI mode, said system further comprising exhaust and intake valve movement including no overlap.

[c6] 6. The system according to claim 1, wherein in HCCI mode, said system further comprising exhaust and intake valve movement including a negative valve overlap of less than approximately 60 cad.

[c7] 7. An intake/exhaust system for a dual-mode homogeneous charge compression ignition (HCCI) engine operable in SI and HCCI modes, said system comprising:
at least one cylinder including at least one intake valve and at least one exhaust valve;
at least one cam profile switching device operatively connected to at least one of said intake and exhaust valves;
at least one cold-air duct connected to said cylinder for

supplying cold air to said cylinder upon opening of said intake valve and a cold-air throttle;
at least one hot-air duct connected to said cylinder for supplying heated air to said cylinder upon opening of said intake valve and a hot-air throttle; and
at least one check valve connected between said cold and hot-air ducts for permitting flow of air between said ducts.

[c8] 8. The system according to claim 7, wherein said cam profile switching device is a roller-roller two-step finger follower.

[c9] 9. The system according to claim 7, further comprising a first cam profile switching device operatively connected to a cold intake valve, and a second cam profile switching device operatively connected to at least two exhaust valves.

[c10] 10. The system according to claim 9, wherein said first cam profile switching device switches an event length of said cold intake valve from approximately 280-320 cad to approximately 150-210 cad, and said second cam profile switching device switches an event length of said exhaust valves from approximately 230-250 cad to approximately 190-220 cad, for combustion mode transition from SI to HCCI mode, and vice-versa for combus-

tion mode transition from HCCI to SI mode.

[c11] 11. The system according to claim 9, wherein said first cam profile switching device switches a normalized valve maximum lift of said cold intake valve from approximately 1 to approximately 0.3-0.7, and said second cam profile switching device switches a normalized valve maximum lift of said exhaust valves from approximately 1 to approximately 0.8-0.95, for combustion mode transition from SI to HCCI mode, and vice-versa for combustion mode transition from HCCI to SI mode.

[c12] 12. The system according to claim 9, wherein said first cam profile switching device switches a valve opening time of said cold intake valve from approximately 0-15 cad to approximately -50-0 cad at top dead center, and said second cam profile switching device switches a valve opening time of said exhaust valves from approximately 50-70 cad to approximately 40-60 cad at bottom dead center, for combustion mode transition from SI to HCCI mode, and vice-versa for combustion mode transition from HCCI to SI mode.

[c13] 13. The system according to claim 9, wherein said first cam profile switching device switches a valve closing time of said cold intake valve from approximately 95-125 cad to approximately 25-45 cad at bottom dead

center, and said second cam profile switching device switches a valve closing time of said exhaust valves from approximately 0-20 cad to approximately -35-0 cad at top dead center, for combustion mode transition from SI to HCCI mode, and vice-versa for combustion mode transition from HCCI to SI mode.

[c14] 14. The system according to claim 7, further comprising first, second and third cam profile switching devices operatively connected to a cold intake valve, a hot intake valve and at least two exhaust valves, respectively.

[c15] 15. The system according to claim 14, wherein said second cam profile switching device switches an event length of said hot intake valve from approximately 170-210 cad to approximately less than 180 cad to begin combustion mode transition from SI to HCCI mode, and vice-versa to begin combustion mode transition from HCCI to SI mode.

[c16] 16. The system according to claim 14, wherein said first cam profile switching device switches an event length of said cold intake valve from approximately 280-320 cad to approximately 150-210 cad, said second cam profile switching device switches an event length of said hot intake valve from approximately less than 180 cad to approximately 170-210 cad, and said third cam profile

switching device switches an event length of said exhaust valves from approximately 230-250 cad to approximately 190-220 cad, for combustion mode transition from SI to HCCI mode, and vice-versa for combustion mode transition from HCCI to SI mode.

[c17] 17. The system according to claim 14, wherein said second cam profile switching device switches a normalized valve maximum lift of said hot intake valve from approximately 0.8-0.95 to approximately less than 0.2 to begin combustion mode transition from SI to HCCI mode, and vice-versa to begin combustion mode transition from HCCI to SI mode.

[c18] 18. The system according to claim 14, wherein said first cam profile switching device switches a normalized valve maximum lift of said cold intake valve from approximately 1 to approximately 0.3-0.7, said second cam profile switching device switches a normalized valve maximum lift of said hot intake valve from approximately less than 0.2 to approximately 0.8-0.95, and said third cam profile switching device switches a normalized valve maximum lift of said exhaust valves from approximately 1 to approximately 0.8-0.95, for combustion mode transition from SI to HCCI mode, and vice-versa for combustion mode transition from HCCI to SI mode.

[c19] 19. The system according to claim 14, wherein said second cam profile switching device switches a valve opening time of said hot intake valve from approximately -35-0 cad to approximately -60-25 cad at top dead center to begin combustion mode transition from SI to HCCI mode, and vice-versa to begin combustion mode transition from HCCI to SI mode.

[c20] 20. The system according to claim 14, wherein said first cam profile switching device switches a valve opening time of said cold intake valve from approximately 0-15 cad to approximately -50-0 cad at top dead center, said second cam profile switching device switches a valve opening time of said hot intake valve from approximately -60-25 cad to approximately -35-0 cad at top dead center, and said third cam profile switching device switches a valve opening time of said exhaust valves from approximately 50-70 cad to approximately 40-60 cad at bottom dead center, for combustion mode transition from SI to HCCI mode, and vice-versa for combustion mode transition from HCCI to SI mode.

[c21] 21. The system according to claim 14, wherein said second cam profile switching device switches a valve closing time of said hot intake valve from approximately 25-45 cad to approximately 0-25 cad at bottom dead center to begin combustion mode transition from SI to HCCI

mode, and vice-versa to begin combustion mode transition from HCCI to SI mode.

[c22] 22. The system according to claim 14, wherein said first cam profile switching device switches a valve closing time of said cold intake valve from approximately 95-125 cad to approximately 25-45 cad at bottom dead center, said second cam profile switching device switches a valve closing time of said hot intake valve from approximately 0-25 cad to approximately 25-45 cad at bottom dead center, and said third cam profile switching device switches a valve closing time of said exhaust valves from approximately 0-20 cad to approximately -35-0 cad at top dead center, for combustion mode transition from SI to HCCI mode, and vice-versa for combustion mode transition from HCCI to SI mode.

[c23] 23. A method of combustion mode transition in a dual-mode homogeneous charge compression ignition (HCCI) operable in SI and HCCI modes, said method comprising the steps of:
providing an intake/exhaust system including:
at least one cylinder including at least one intake valve and at least one exhaust valve;
at least one cam profile switching device operatively connected to at least one of said intake and exhaust valves;

at least one cold-air duct connected to said cylinder for supplying cold air to said cylinder upon opening of said intake valve and a cold-air throttle;
at least one hot-air duct connected to said cylinder for supplying heated air to said cylinder upon opening of said intake valve and a hot-air throttle; and
at least one check valve connected between said cold and hot-air ducts for permitting flow of air between said ducts; and
operating said cold-air and hot-air throttles, and said check valve to control temperature and flow of air supplied to said cylinder.

[c24] 24. An intake/exhaust system for a dual-mode homogeneous charge compression ignition (HCCI) engine operable in SI and HCCI modes, said system comprising:
a source for supplying air to the engine;
a coolant heat exchanger for cooling air from said source, said cooled air being supplied to an exhaust heat exchanger;
a camless valve actuator for controlling at least one hot and at least one cold intake valve;
at least one control valve for controlling air through said exhaust heat exchanger and said source to supply heated air via a hot intake manifold directly to at least one cylinder upon opening of said hot intake valve; and

a cold intake manifold for directly supplying air from said source to said cylinder upon opening of said cold intake valve so as to supply air at a first temperature to the engine for operation in SI mode and air at a second temperature to the engine for operation in HCCI mode.

[c25] 25. A method of combustion mode transition in a dual-mode homogeneous charge compression ignition (HCCI) engine operable in SI and HCCI modes, said method comprising the steps of:
supplying air to the engine by a source;
cooling the supplied air by a coolant heat exchanger;
supplying the cooled air to an exhaust heat exchanger;
controlling at least one hot and at least one cold intake valve by a camless valve actuator;
controlling air through said exhaust heat exchanger and said source by at least one control valve to supply heated air via a hot intake manifold directly to at least one cylinder upon opening of said hot intake valve; and
supplying air from said source to said cylinder via a cold intake manifold upon opening of said cold intake valve so as to supply air at a first temperature to the engine for operation in SI mode and air at a second temperature to the engine for operation in HCCI mode.

[c26] 26. The method according to claim 25, for operation in SI mode, closing said hot intake valve.

[c27] 27. The method according to claim 25, for operation in HCCI mode, closing said cold intake valve.

[c28] 28. The method according to claim 25, for transition from SI to HCCI mode and vice-versa, adjusting valve timings of said cold and hot intake valves to obtain a required temperature for operation in SI or HCCI mode.